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ABSTRACT

Scholastic aptitude, mathematics achievement, and high school rank were used as college entry predictors of achievement in a foundation engineering curriculum for 1,779 freshmen enrolling in engineering at the University of Texas at Austin during the years 1974-77. Achievement in the foundation engineering curriculum was measured by taking grade-point-averages from appropriate mathematics, physics, and engineering mechanics courses. The Mathematics Achievement Test proved to be the primary predictor of academic performance. Achievement in the foundation engineering courses was the best predictor of retention in engineering school, though first-year grade-point-average was nearly as efficient. (Author/MK)

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# MATHEMATICS ACHIEVEMENT LEVEL TESTING AS A PREDICTOR OF ACADEMIC PERFORMANCE AND RETENTION IN ENGINEERING STUDENTS

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## Abstract

Scholastic aptitude, mathematics achievement, and high school rank were used as college entry predictors of achievement in a foundation engineering curriculum (mathematics, physics, and engineering mechanics grade-point averages) for 1,779 freshmen enrolling in engineering at The University of Texas at Austin during the years 1974-1977. The Mathematics Achievement Test proved to be the primary predictor of academic performance. Achievement in the foundation engineering courses was the best predictor of retention in engineering school, though first year grade-point average was nearly as efficient.

# MATHEMATICS ACHIEVEMENT LEVEL TESTING AS A PREDICTOR OF ACADEMIC PERFORMANCE AND RETENTION IN ENGINEERING STUDENTS

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The importance of mathematical skill to student success in engineering has been well documented (Fowler, Jong, and Rogers, 1976; Snyder and Merriam, 1978; Troutman, 1978). The study of physics and engineering mechanics are other important content areas for all student engineers, though less investigated by researchers. The level of student achievement in mathematics, engineering mechanics, and physics coursework can be considered to be the essential component in developing a supportive foundation for future engineering specialization. A combination of these course areas may be referred to as a "basic engineering curriculum" (BEC). The prediction of successful achievement in such a basic engineering curriculum, as well as retention in the engineering program, become natural foci of study in most schools of engineering.

The literature bears witness to the fact that many studies of engineering student achievement have been conducted using traditional predictors of standardized college entrance aptitude tests and high school rank. Yet, the studies of both engineering students and university students in general reveal conflicting results as to the efficacy of these individual predictors. Price and Kim (1976) and Troutman (1978) have found college entrance aptitude examinations to be the best predictor of college achievement, while Larson and Scontrino (1976) and Lunneborg (1977) found high school grades to be more useful. The prediction of retention from entry data is even more difficult, for many personal

characteristics affect student attrition besides aptitude level.

While it must be cautioned that no preexisting variable or measure can accurately predict all future academic performance in students, the inclusion of a mathematics achievement test in predicting engineering success seems warranted. Mathematics skill is an integral part of the engineering curriculum. While it might be argued that there is little actual distinction between standardized aptitude and achievement measures in mathematics, the results from this study of 1,779 engineering students at The University of Texas at Austin suggest otherwise. The use of an achievement measure in mathematics proved to be the best single predictor of achievement in the basic engineering curriculum.

Students entering The University of Texas at Austin as freshmen in the fall semesters of the years 1974 through 1977 were given the Mathematics Achievement Test, Level I (Math I) as an aid to appropriate placement in precalculus or calculus sequences of mathematics instruction. (This College Entrance Examination Board test covers the typical content taught in three years of high school mathematics coursework.) In addition, the traditional measures of the Scholastic Aptitude Test, verbal and quantitative subscores (SAT-V and SAT-M) and high school rank (HSR) were required as entry level criteria. High school rank was computed by the formula $(1 - \frac{\text{rank in class}}{\text{size of class}}) \times 100$. Academic performance for all registered courses and records of attrition and retention were maintained for students through the fall semester of 1978. Three patterns of retention and five patterns of attrition were identified, but for purposes of this analysis, a dichotomy was formed by combining the five attrition patterns into one group, and the three retention patterns into another group.

All of the variables in the study were intercorrelated and descriptive statistics obtained. Multiple regression statistical procedures were used to analyze the contributions of the Math I, SAT-M, SAT-V, and HSR to academic success for the criterion of a combination of 12 foundation courses in the areas of mathematics, physics, and engineering mechanics (BEC). The same techniques were used for predicting student attrition or retention with BEC achievement, Math I, SAT-M, SAT-V, and HSR as predictors in one equation, and first year grade-point average (FYR/GPA) and entry measures as predictors in a second equation for the criterion of retention.

## Results

Table 1 gives the correlation of each of the Math I, SAT-M, SAT-V, and HSR variables to future achievement in several content areas in the engineering curriculum. As can be observed, the Math I measure was related more positively to achievement in all areas.

Insert Table 1 here

Table 2 provides summary data from a multiple regression equation using the combination of mathematics, physics, and engineering mechanics grade-point averages (BEC/GPA) as the criterion and Math I, SAT-M, SAT-V, and HSR as predictors. In stepwise multiple regression procedures, it is possible for a predictor correlating less highly with the criterion to enter into an equation ahead of a predictor associating more highly with that same criterion. This situation occurs in the case of high school rank, which correlates less highly with the BEC criterion than the mathematics portion of the SAT (HSR .350; SAT-M .445). However, HSR contributes an independent dimension to the pre-

diction of achievement while the SAT-M measure shares commonality in prediction with the Math I test. Together, three of the entry predictors explained 32 percent of the variance in the basic engineering curriculum GPA (R = .562), while the Math I alone explained 26 percent (R = .514). The SAT-V did not increase the efficiency of prediction significantly when included in the equation.

Insert Table 2 here

Table 3 provides the relative contributions of achievement in the basic engineering courses (BEC/GPA), Math I, SAT-M, SAT-V, and HSR to the prediction of retention. (The criterion in Table 2 is being used as one of the predictors in Table 3.) Though not presented here, it was found when using only entry data predictors that the Math I contributed slightly more (5.4% of the variance) to the prediction of student retention than did the other three predictor variables. However, all four of the predictor variables together explained only 6.3% of the variance in student retention. With the addition of the basic engineering curriculum GPA as a predictor of retention, the amount of variance being accounted for increased to 19 percent. However, it is achievement in the basic engineering curriculum that is the single significant predictor of retention. Entry data contributed very little independent information to prediction when combined with performance in basic engineering courses ($R^2$ = .191 vs. $R^2$ = 190 BEC/GPA alone). The multiple correlation for the equation was .435.

Insert Table 3 here

Table 4 provides a similar summary table for the criterion of retention with FYR/GPA and entry measures as the predictors. FYR/GPA combined with SAT-V and Math I to account for 17 percent of the variance in retention (R=.417).

Insert Table 4 here

## Conclusions

The results from this study give support to the inclusion of mathematics achievement level testing as useful for prediction of engineering success. The Math I measure used in this study correlated more highly with engineering academic achievement than did the traditional predictors of scholastic aptitude and high school rank and emerged as the most important predictor of achievement in a combination of basic engineering courses. While guidance personnel might be interested in the parsimonious use of a single measure to meet the dual purpose of placement and prediction, the findings from this study suggest that a combination of the traditional predictors of high school rank and scholastic aptitude with mathematics achievement testing is likely to provide even greater efficacy in predicting academic success in engineering.

Grades in basic engineering courses proved to be the best single predictor of retention in engineering. However, it must be recognized that attrition and retention in engineering are related to a multiplicity of factors. The contribution of measures used in this study to the explanation of retention was only 19 percent with the inclusion of BEC; and 17 percent with FYR/GPA. The consideration of non-academic information with entry data, such as social and personality factors, may increase retention predictive efficiency to some extent (Foster, 1976; Neely, 1977; Peng and Fetters, 1978). Nevertheless, entry level aptitude scores and course grades will always be more closely related than entry level data is related to attrition/retention, for non-academic variables

can affect student attrition and retention. Thus, the prediction of retention in engineering will always remain a more complex task than that of predicting academic success.

Table 1

Correlations of Mean Aptitude Scores and Academic Performance of 1,779 Freshman Engineering Students Entering U.T. Austin Fall Semesters, 1974-1977

| Prior Aptitude/ Achievement Measures | Mathematics GPA (N=1,718) | Physics GPA (N=1,567) | Engineering Mechanics GPA (N=1,149) | Basic Engineering Curriculum GPA (N=1,749) |
|---|---|---|---|---|
| | correlation | correlation | correlation | correlation |
| Math I | .476 | .355 | .437 | .514 |
| SAT-V | .253 | .227 | .258 | 294 |
| SAT-M | .406 | .299 | .380 | .445 |
| HSR | .351 | .268 | .269 | .350 |

Table 2

Prediction of the Basic Engineering Curriculum Grade-Point Average Earned by 1,779 Freshman Engineering Students Entering U.T. Austin Fall Semesters, 1974-1977

| Predictor | Correlation (r) | Multiple Correlation (R) | Squared Multiple Correlation ($R^2$) | Increase in Squared Multiple Correlation ($R^2$ change) | F-Ratio | Significance (p) |
|---|---|---|---|---|---|---|
| Math I | .514 | .514 | .264 | .264 | 627.579 | $<.001$ |
| HSR | .350 | .556 | .310 | .046 | 114.758 | $<.001$ |
| SAT-M | .445 | .562 | .316 | .006 | 16.499 | $<.001$ |
| SAT-V | .294 | .562 | .316 | .000 | .003 | .960 |

Table 3

Prediction of Retention for 1,779 Freshman Engineering Students Entering U.T. Austin Fall Semesters, 1974-1977

| Predictor | Correlation (r) | Multiple Correlation (R) | Squared Multiple Correlation ($R^2$) | Increase in Squared Multiple Correlation ($R^2$ change) | F-Ratio | Significance (p) |
|---|---|---|---|---|---|---|
| BEC | .436 | .436 | .190 | .190 | 416.79 | .001 |
| SAT-V | .091 | .437 | .191 | .001 | 2.90 | .089 |
| SAT-M | .192 | .438 | .192 | .001 | .677 | .411 |
| HSR | .137 | .438 | .192 | <.001 | .278 | .598 |
| Math I | .220 | .438 | .192 | <.001 | .052 | .820 |

Table 4

Prediction of Retention for 1,779 Freshman Engineering Students Entering U.T. Austin Fall Semesters, 1974-1977

| Predictor | Correlation (r) | Multiple Correlation (R) | Squared Multiple Correlation ($R^2$) | Increase in Squared Multiple Correlation ($R^2$ change) | F-Ratio | Significance (p) |
|---|---|---|---|---|---|---|
| FYR/GPA | .410 | .410 | .168 | .168 | 359.88 | < .001 |
| SAT-V | .090 | .414 | .171 | .003 | 5.93 | .015 |
| Math I | .220 | .417 | .173 | .002 | 4.93 | .027 |
| HSR | .137 | .417 | .174 | .001 | 1.37 | .242 |
| SAT-M | .192 | .418 | .174 | < .001 | 0.72 | .396 |

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